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FOREST INSECT INVESTIGATIONS

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FOREST INSECT CONDITIONS, SEQUOIA NATIONAL PARK

SEASON OF 1930

by

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GENERAL SUMMARY

The following report covers the results and recommendations of the 1930 forest insect reconnaissance of Sequoia National Park, California.

Since 1917, when the first insect survey and control work was conducted on the Sequoia, there has been a decided increase in forest insect infestations, particularly in yellow pine. From 1918 until 1928 no actual control work was conducted, although unsuccessful attempts were made to secure funds.

In 1928 there occurred a conspicuous increase in pine beetle infestations, and control was inaugurated at Lodgepole Camp through labor contributed from the ranger force. In 1929 a small allotment of funds was secured, and control work up to the present time has centered around Lodgepole Camp. At the same time a close watch has been kept on insect conditions in other forest areas, which are covered in part in the 1930 survey and report.

The insects presenting the most serious problems are the bark beetles attacking western yellow pine, sugar pine, lodgepole pine and Jeffrey pine. As each of the above trees is the host of special bark beetles, it is necessary to treat each species as a separate problem.

A small center of mountain pine beetle infestation is building up at Horse Creek which threatens the mature lodgepole pine forest on the Hockett Meadow plateau. This area should be treated next spring if funds are available.

The western pine beetle infestation in yellow pine has increased tenfold in the Southfork and Eastfork of the Kaweah during the past two seasons. On the other hand, the infestations in the Middlefork and Marblefork have not increased materially during the same period, though some evidence was found to indicate that they are now starting to build up more serious losses.

Plans that are proposed for the spring season of 1931 consider: first, to do no control work at all, leaving these infestations to run their course; and second, to treat all infestations within the Park, regardless of accessibility or value of cover, which would cost around $11,640. The former of these plans would not safeguard the more important park values which are at stake. The latter, because of inaccessibility and low value of forest cover on certain of the infested areas, involves an expense which may not be warranted on the basis of the results to be expected.

Three alternative plans are therefore proposed:

1. To treat the more accessible and intensively-used yellow pine areas and the lodgepole pine center at Horse Creek, which would cost $2,740;

2. To treat in addition to the above areas the Southfork watershed, which though now inaccessible is being considered for future park development, and would involve a total project cost estimated at $4,110; and

3. To treat the same area as above, except to substitute for the Southfork the north half of the Eastfork watershed, which is now fairly accessible and would involve a total cost estimated at $3,700.

Decision as to which of these plans are adopted involves a consideration of the objectives and policy of protection work in national parks which is discussed in this report.

FOREST INSECT CONDITIONS, SEQUOIA NATIONAL PARK
SEASON OF 1930

Introduction

In surveys of forest insect infestations within Sequoia National Park it is necessary to consider not one problem, but a group of problems more or less distinct as to character. This is due to the fact that there are five species of bark beetles capable of aggressively attacking six species of conifers, and that each of these insects may develop epidemic conditions independently of the others. At the same time it is necessary to recognize that the intensity of these infestations varies from year to year, so that conditions found on an area one season may differ from those of the preceding or following year. The present survey and recommendations apply only to the more important situations found during the season of 1930 and to such control work as can be carried out to advantage during the winter and spring period of 1930-31.

History of Past Conditions, Surveys and Control Work

Even to the casual observer it is obvious that a very decided change has developed during the past two years in certain areas of the Park in the status of insect infestations. This change is due mainly to the increase of the western pine beetle in yellow pine areas. It is doubtful if an epidemic of similar intensity has occurred within the history of the present yellow pine stand. What is known, on the basis of actual surveys, of the history of bark beetle infestations on the Sequoia extends over a period including the past fifteen years. The first reconnaissance of conditions in the yellow pine-sugar pine type was made in 1917 cooperatively by the Forest Service, National Park Service and Bureau of Entomology. Following methods similar to those employed in the 1930 survey, the losses sustained in this type during 1916 were estimated at 342 yellow pines with a volume of 1,978,000 board feet, and 310 sugar pines with a volume of 1,264,000 board feet.

The survey of 1917 indicated that in the Middlefork of the Kaweah the losses of 1917 had increased 300 per cent over those of 1916, and that an epidemic was threatening. Control work was recommended for this area, covering about 11,000 acres. This work was carried out during the spring of 1918, and 135 infested trees were treated at a cost of $1,330.60. A detailed cruise of the control area made in 1919 showed that during the season immediately following the control work an 81 per cent decline in yellow pine losses resulted. The insects, therefore, killed only one-fifth the amount of timber that was destroyed during the season preceding control.

During the season of 1919 some work of an experimental nature was carried on in the Marblefork area under the direction of the Bureau of Entomology, mainly as a test of the newly-discovered method of treating infested bark by the use of solar heat. No further control work was carried on within the Park until the fall of 1928, when protection of the Lodgepole Camp area was undertaken.

Examinations to check up on the effects of control work were made by the Bureau of Entomology in 1918, 1919 and 1920. In the fall of 1928 a brief survey was made of the Marblefork, Horse and Yucca Creek basins by the Bureau at the request of Superintendent White. An allotment of $1,500 to carry on a program of maintenance protection was requested, but was not made available. In the fall of 1928 surveys of the more important areas were started by Acting Forester Bean, and these have been continued annually up to the present time.

From 1919 until the fall of 1928 infestations within the yellow pine were fairly endemic, and no conspicuous losses occurred beyond the occasional dying of single trees or small groups. The most serious losses during this period developed in sugar pine about 1924-28, due to the mountain pine beetle.

The first indications of a change in the status of the yellow pine infestations became apparent in the spring of 1929. This condition at first centered around the southern slope of Milk Ranch Mountain and the Oriole Lake area, where, instead of the usual number of scattered, isolated trees dying in each watershed, conspicuous groups of ten to fifteen trees with sorrel foliage became prevalent. These groups were killed by attacks of the western pine beetle in the fall of 1928, and contained broods which emerged and attacked still larger groups of trees in the early summer of 1929. During that season the epidemic became established in a large part of the Eastfork drainage; and at the same time Paradise Creek, an adjoining tributary of the Middlefork drainage, sustained the loss of a very high percentage of a sparse yellow pine cover. The 1930 infestation is still aggressive, and shows very little indication of a decline setting in from natural causes.

Conditions as they exist in the various watersheds and in other types of infestation will be discussed in a later section of this report.

Area Covered and Methods Used in 1930 Insect Control Survey

This examination, upon which are based the present report and recommendations, was made during the period from September 17 to October 5, 1930, by Park Naturalist Bean, G.R. Struble and J.E. Miller of the Bureau of Entomology. The area covered includes the entire Kaweah watershed. This limits the survey to the more accessible and valuable Park areas that are now threatened by epidemic infestations. The Kern River country was left out of consideration mainly because that section of the park is visited by a much smaller number of people, and because a reconnaissance by Mr. Bean in 1929 indicated that the Jeffrey pine and lodgepole pine forest of the Kern contained no infestations that would in any way compare in seriousness with those in the canyons of the Kaweah.

The yellow pine-sugar pine-fir type of the Kaweah drainage forms amphitheater-like belts which contour the tributary watersheds between the elevations of 5,000 and 7,000 feet. Due to the rough and broken topography of the region, the topographic method of tree counting was used, so most of the timbered area can be seen from vantage points and a high percentage of the red and fading insect-killed trees can be counted. These counts were supplemented by a hundred per cent cruise of sample areas, where all trees killed during the past two seasons were examined and marked to determine (1) the primary tree-killing insects; (2) the average diameter and volume of the recently-killed trees; and (3) the percentage of the total number of red and fading trees that were counted from view points. The total number of trees within each watershed was then estimated, using a factor based upon the percentage of trees actually counted. This is the only method which can be used in this sort of topography without going to the expense of examining and marking every tree by a hundred per cent cruise of each watershed--an expense which is warranted only when marking infested trees in advance of actual control work. The estimate based upon these topographic surveys will usually come within 25 per cent of the number of trees marked by a hundred per cent cruise of the same area.

In the lodgepole pine type, however, it is not possible to arrive at satisfactory estimates without relying upon strip cruises or hundred per cent cruises of the entire area. This is due to the fact that nearly all trees attacked during the current season do not turn color until the following spring, and can be detected in the fall only by an examination of the main trunk for pitch tubes. The lodgepole areas also occur around meadows and on benches where topographic viewing of the type is not feasible.

More Important Insect Problems of the Sequoia

Fortunately the Big Tree enjoys remarkable immunity from tree-killing insects. The Giant Forest can therefore be disregarded in any consideration of insect attacks, except for certain bark beetles and borers which work in windthrown or broken trees. However, practically all other conifers within the park, especially the pine types which form the front of the Giant Forest, are subject to infestations which may at times become epidemic. The more important problems can be listed as follows:

	Primary Insect	Host Tree Attacked
1.	Western Pine Beetle (Dendroctonus brevicomis Lec.)	Western Yellow Pine
2.	Mountain Pine Beetle (Dendroctonus monticolae Hopk.)	Sugar Pine
3.	do do	Lodgepole Pine
4.	Jeffrey Pine Beetle (Dendroctonus jeffreyi Hopk.)	Jeffrey Pine
5.	Fir Engraver (Scolytus ventralis Lec.)	White and Red Fir
6.	Pine Engravers (Ips spp.)	All Pines

Although these problems are all more or less associated in the mixed stands, they are entomologically distinct, requiring individual consideration in the formulation of control measures. They are therefore treated separately in this report.

Western Pine Beetle in Yellow Pine

At present the most serious situations in the Parks are due to this insect. The rate at which its population may increase are potentially great, as this bark beetle develops at least two generations each season in the Southern Sierra region. When the new adult beetles emerge in May from trees killed the preceding fall, they attack and kill another series of trees within a few weeks. The new broods develop in these trees during the early summer, and a new crop of beetles begin to emerge by midsummer. Another series of trees is then attacked. Part of the infestation may emerge late in the fall and attack still a third series of trees before winter. For the purpose of cruising and estimates the trees killed each season can be grouped in two classes: (1) Summer brood trees which are attacked and abandoned before fall, and (2) Winter brood trees which are attacked late in the summer or fall in which the broods remain during the subsequent winter period.

In the supplement to this report will be found a tabulation of the trees counted on each watershed by topographic viewing, together with the data obtained from check areas. This includes mainly trees that were killed during the season of 1929 and the first part of the season of 1930. (In surveys made during September and October the summer-brood trees of the current season can be seen, together with part of the winter-brood trees.) In these estimates the number of trees counted have been separated into the two seasons represented, and the figures for 1930 have been supplemented, in order to determine the total loss for the current season, using as a basis the ratios found on the check areas. As a rule about 70 per cent of the current seasonal loss is visible in September and early October, and a fair estimate can be arrived at by increasing the number of trees counted for that year by 30 per cent. The following table gives the estimates arrived at in this way for each watershed, so as to include the number and volume of trees killed during each of the past two seasons, the number of trees containing overwintering broods from 1930 which must be treated if control is undertaken, and the approximate cost of control work for the ensuing winter and spring period.

TABLE I

Western Pine Beetle Estimates for 1929 and 1930

Watershed	Southfork of Kaweah	Eastfork Kaweah	Middlefork of Kaweah	Marblefork & Yucca Cr.	Totals
Acreage of pine type	10,000	16,000	11,000	17,500	54,500
Number trees counted	327	1,917	752	298	3,294
Average volume per tree b.f.	1,410	1,410	1,500	1,740	
1929 loss: Trees	265	1,035	406	72	1,778
Volume b.f.	374,560	1,459,600	609,150	126,670	2,570,050
1930 loss: Trees	294	1,155	443	175	2,067
Volume b.f.	413,719	1,628,000	665,310	305,750	3,012,770
Total both years: Trees	559	2,190	849	247	4,220
Volume b.f.	788,370	3,087,600	1,274,430	432,420	5,582,820
1930 overwintering: Trees	140	660	225	90	1,105
Volume b.f.	197,400	916,500	347,600	156,600	1,618,000
Estimated control cost per tree	$8.00	$8.00	$8.00	$8.00	
Total cost for area	$1120.00	$5,200.00	$1,800.00	$720.00	$8,840.00

Mountain Pine Beetle in Sugar Pine

Average volume per tree b.f.	3,000	2,500	3,000	3,000	
Number trees counted in survey	85	330	95	30	530
1929 loss: Trees	51	231	57	18	357
Volume b.f.	151,890	577,500	171,000	54,000	954,390
1930 loss: Trees	45	225	58	18	346
Volume b.f.	135,960	564,500	174,000	54,000	928,460
Total both years: Trees	96	456	115	36	703
Volume b.f.	287,850	1,140,000	345,000	108,000	1,882,850
1930 overwintering: Trees	35	115	60	20	230
Volume b.f.	75,900	287,500	18,000	60,000	440,500
Control cost per tree	$10.00	$10.00	$10.00	$10.00	
Total cost	$350.00	$1,150.00	$600.00	$200.00	$2,300.00

It is possible to arrive at some indication of the recent change in conditions by comparing the estimates of the 1930 survey with those of the survey made in 1917. The losses in the four watersheds involved compare as follows:

Area	Number of yellow pine trees estimated by topographic survey	
	1917	1930
Southfork of Kaweah	36	827
Eastfork	190	1,917
Middlefork	480	752
Marblefork and Yucca Creek	352	808
Totals	1,058	3,304

The history of the intervening infestations during this 14-year period has not been determined by actual surveys, but it is obvious that this increase in losses has not built up gradually, but is the result of a sudden epidemic which developed during the past two seasons, mainly in the two southern watersheds of the park. Both the Southfork and the Eastfork show losses ten times as great as those that were found on the same areas in 1917. In the Middlefork the current losses are about twice those shown by the old survey, while in the Marblefork area they are even less than they were fourteen years ago. It is difficult to account for this disparity in the intensity of the infestation within the different watersheds, as all show great similarity in soil type and precipitation factors. A comparison of the annual rings indicates that the conditions influencing growth have not varied greatly in the four watersheds. It seems altogether probable that the infestation in the two southern watersheds gained momentum through force of numbers, and that at any time we may expect epidemic conditions to develop in the Middle fork and Marblefork areas. In fact, conditions noted this fall near Colony Mill Point (where a decided local increase occurred in 1930) may be the forerunner of this condition in the Marblefork area.

It is of course difficult if not impossible to predict the future course of these infestations if no control action is taken. In the Southfork and Eastfork areas the epidemic may have reached its peak, as the 1930 losses do not greatly exceed those for 1929. The Middlefork shows a similar status. Usually western pine beetle epidemics decline from natural causes after two or three seasons of high losses; but there is no assurance that this will be the case on the Sequoia areas. The heaviest infestation of which we have a record--that on the Modoc National Forest from 1924 to 1929--increased for five successive seasons before natural factors gained the upper hand. If an epidemic starts now on the Marblefork it will probably run for several years before we can expect relief, unless the situation is taken in hand by prompt control measures.

The methods of control that have so far been proven to best suited to the control of this beetle consist of felling, peeling and burning the bark of infested trees during the late fall, winter and spring periods. The purpose of this work is to reduce the beetle population within the selected area and not to save the trees which have already been attacked. Once the beetles concentrate in numbers on an individual tree it is killed in a few days, and no method has yet been found which will save it. By destroying the broods before they can develop and emerge from this tree, their attacks on other trees are prevented. The cost of treatment will be expensive under the conditions existing on these areas, due to the size of the infested trees and the fact that many are located in rough and nearly inaccessible country. The estimated cost of $8.00 per tree may be somewhat conservative, but as the 1930 infestation is attacking trees that average smaller in size than on previous projects in this park, the cost should not materially exceed this figure.

In considering the advisability of control work we can only assume that the results obtained will be comparable to those secured on past projects, where the same methods have been applied to the western pine beetle under similar conditions. A reduction of 60 to 80 per cent of the losses can be expected during the first season following the initial control work.

Past experience also indicates that it will not pay to start work in any of these watersheds, however, unless an area large enough to form a suitable infestation unit is covered. This will mean working over an area the size of the Marblefork-Tucca Creek Unit, or else one that is effectively protected by type barriers which will act as a check to the spread of beetles from adjacent unworked territory into the control zone. At the same time it must be recognized that the initial work of the first year will not put an end to the infestation, even where suitable control units are selected. For these reasons it does not seem advisable to initiate work on any of these areas unless provision is made for as much work as is necessary in subsequent years to prevent the infestation from again building back to the epidemic stage. The present estimates apply only to the initial control work for the 1930 overwintering infestation. The needs for subsequent maintenance work cannot be definitely foreseen at this time, but we can expect them to run from 10 to 25 per cent of the initial control costs.

The extent of the program to be undertaken depends upon the considerations involved in the national park policy of protection discussed in a later section of this report. Each of the four watersheds composes a fairly comprehensive unit with definite boundaries, so that it is possible to consider each one separately in a general control plan. The most urgent need for control work now appears to be in the Marblefork area, both because of the high values to the Park which are threatened and the opportunity of checking an infestation which is apparently due to increase.

Mountain Pine Beetle in Sugar Pine

As both sugar pine and yellow pine occur in mixed stands, the infestations of the mountain pine and western pine beetles occur together in the same watersheds. In habits, however, the two insects are quite different, and the infestations of the two do not always follow the same cycle in the same areas. Just at present the mountain pine beetle is a minor factor in the situation. However, many black-topped trees are standing in the Marblefork and Middlefork drainages which were killed by the mountain pine beetle about 1924 to 1926. This infestation has decreased during more recent years. In the Eastfork drainage, however, the mountain pine beetle has increased perceptibly along with the western pine beetle epidemic, and in the recent survey losses in sugar pine were found to be about four times as great as they were in 1917.

The mountain pine beetle occasionally attacks yellow pine, but to a negligible degree in this Park. It occurs only in small, slow-growing trees, and does not affect the present situation to an appreciable degree.

A summary of estimates of losses and cost of control for the mountain pine beetle in sugar pine is included in Table I of this report. The same results may be expected from initial and maintenance control of the mountain pine beetle in sugar pine as for the western pine beetle. In any protection program treatment of the infestation in sugar pine should be included along with that of the western pine beetle, as the same objectives are involved in these watersheds. It will be necessary in either case to cover the same areas with control cruises, as the two beetles occur in mixed type with infested trees standing on the same slopes. Primary consideration should be given for the present, however, to checking the western pine beetle epidemic, with control of the mountain pine beetle carried on incidentally to this program.

Jeffrey Pine Beetle in Jeffrey Pine

The habits of this bark beetle are similar to the mountain pine beetle, but it attacks Jeffrey pine only. It is found mainly at the higher elevations, where Jeffrey pine comes in above the yellow pine-sugar pine belt in mixture with fir.

The upper Marblefork basin carried an infestation of this beetle which was depleting the trees that form part of the cover for the Lodgepole Campground (see Photo No. 3). This was cleaned up during the fall of 1930 and the work extended for some distance from the campground itself. A total of 56 trees were treated at a cost of $335.00. Maintenance work will be necessary each season to prevent the beetle from working back into the campground area. Work should also be considered along the route of the General's Highway, as part of this road runs through Jeffrey pine forests where the existing cover is sparse.

Some Jeffrey pines are included with yellow pine in the estimates for the four watersheds, as it is not possible to separate the two tree species in topographic viewing. Cost of this control work is therefore included in the estimates given in Table I.

Mountain Pine Beetle in Lodgepole Pine

In other regions, such as Crater Lake and Yosemite National Parks, forests have been killed by the mountain pine beetle. It differs in behavior from the same species in sugar pine in that in the pure lodgepole stands great epidemics build up which maintain their momentum for years. Lodgepole in the Southern Sierra rarely grows in extensive belts but occurs in small areas surrounding meadows and in stringers along streams. The largest area of mature lodgepole in the Sequoia covers the Hockett Meadow plateau, forming a belt about eight miles long by two miles wide. It is in mature lodgepole of this type that mountain pine beetle epidemics develop most rapidly, and usually kill around 90 per cent of the trees before they subside (see Photo No. 6).

In 1928 group killing of trees in the campground cover at Lodgepole Camp was noted. Forty-five trees were found to be infested at Lodgepole Camp and about 20 at Willow Meadow, 1½ miles distant. All trees at Lodgepole Camp were treated inthe fall of 1928, but no work was done at Willow Meadow. In the fall of 1929 only five newly-infested trees were found in the same area at Lodgepole Camp, while the number at Willow Meadow had increased to 38. In 1930 nine trees were found at Lodgepole and 36 at Willow Meadow. This fall, however, both the Lodgepole Camp and Willow Meadow infestations were cleaned up, which should put an end to the major losses in this area.

Another center of lodgepole pine infestation exists at Horse Creek, about two miles north of Hockett Meadow, which is slowly building up to an epidemic condition. This infestation was first surveyed in 1928, when a center of approximately 100 trees was found on an area of 60 acres. During the season of 1930 this infestation increased around 80 per cent. The mature lodgepole around Hockett Meadow is exposed to the spread of this epidemic, and unless control is undertaken in the spring of 1931 the infestation may spread further. It is estimated that it will be necessary to treat 150 trees at a cost of $4.00 per tree, requiring an allotment of $600.

Pine Engraver Beetles

The engraver beetles (Ips oregoni, Ips confusus and Ips emarginatus) attack all pines and are often associated in a secondary capacity with the Dendroctonus beetles in epidemic situations. At times, however, sporadic outbreaks of Ips may occur which result in the top-killing of large trees or the entire killing of small trees of pole sizes. These outbreaks are usually the result of a windfall or slash condition, where the engraver beetles have multiplied their numbers in recently-felled logs and limbs and then attacked standing trees in the vicinity. This infestation is not at present of serious importance on the Sequoia; it is mentioned mainly because the trouble is likely to occur in connection with clearing for road and trail construction. If the logs and other slash left along the right of way are disposed of, thus depriving the insects of breeding places whence they might emerge, the attacks in standing trees along these operations may be greatly diminished.

Prompt removal of logs from the forest, or leaving them during the summer period where they are fully exposed to the hot sun if they cannot be removed, are the best measures for preventing the attack. If the logs become infested in the woods, their removal, or the burning of the infested bark, are the measures best suited to protect standing trees along the right of way.

Fir Engraver Beetle

Both white and red fir in many localities of the Sequoia are heavily infested by this bark beetle. Top-killing is the more common type of injury, but often the entire tree is killed by the supplemental attack of a cerambycid borer after the upper bole has been killed by the fir engraver. The problem is further complicated by a cambium-killing fungus which the engraver beetle establishes in the tree when it cuts the egg gallery under the bark.

No control methods have as yet been tried out for the fir engraver. The obvious method of control would be to cut and burn the infested trees, as in other bark beetle infestations. This method, however, involves complications, as many green trees within the forest are but partially attacked, and it is doubtful if they can be located by the ordinary methods for cruising infested trees. A thorough clean-up of all the infestation within an area would involve the sacrifice of these partially-attacked trees, which sometimes live for many years if no further attacks are made by insects. At present the only measures which appear to be warranted are those which would be used in the forest sanitation of camp grounds and intensively-used areas. In these areas dead and dying trees should be felled and removed from the grounds, and this work should be done at the time when the broods of the fir engraver will be destroyed. A great deal of this work can be done to good advantage around the Giant Forest.

Proposed Plans for Control Work, Spring Season, 1931

Although forest insect surveys, followed by a very limited amount of control work, have been in progress on the Sequoia for the past fourteen years, no clearcut policy has been set up which defines the objectives for this sort of protection work.

The considerations involved in any proposed plan of action are: first, its entomological feasibility, and second, the value of expected results to the use and future development of the national park. Several alternative plans and their cost will first be considered, and a discussion of the national park protection policy which they involve will be taken up in a later section of this report.

The plan of maintaining control on the Lodgepole Campground has already been adopted on the Sequoia. Worthwhile results were demonstrated in 1928-29, and it will be necessary to carry on a small amount of work each year to keep this area clean.

Control of the mountain pine beetle infestation at Horse Creek (Area 5, see map) in order to protect the lodgepole forest on the Hockett Plateau, has been decided upon. It is estimated that this project, if carried out in the spring of 1931, will require the treatment of 150 trees at a cost of $600.

The western pine beetle epidemic in yellow pine and the associated infestation of the mountain pine beetle in sugar pine on the Kaweah watersheds present the most serious situation within the Park, and the most costly if control measures are undertaken. From an entomological standpoint at least five alternative plans can be considered. Because there is no question concerning treatment of Horse Creek, Area 5 is included in each plan except Plan I.

	No. Trees			
	Y.P.	S.P.	L.P.	Est.Cost
Plan I Conduct no control work whatever, leaving nature to work out its own adjustment of this disturbance. This plan will involve no direct expense, and no allotment of funds will be necessary. The results to be expected from this course of action can be predicted only upon the basis of what has happened in similar situations in other areas. We can expect the epidemic in the Southfork and Westfork to subside within the next few years. The losses, however, will probably increase in the Middlefork and Marblefork. In all watersheds these epidemic infestations are due to burn out in time, leaving many dead trees which will be slowly replaced by the growth of new ones. The complete loss of the forest cover is hardly possible as a result of bark beetles alone, although on the border sites, where conditions are unfavorable for growth, brush types will probably capture the ground cover.				
Plan II Treat all epidemic or threatening infestations, regardless of accessibility or value of forest cover. As a result of this campaign we can expect a reduction in losses next season of from 60 to 80 per cent. This initial control work, however, will not prevent the infestation from building back to the epidemic status if conditions again favor an increase. Maintenance control should therefore be provided for, and for the first year will probably cost around 25 per cent of the initial control work.	1105	220	150	$11,640

	No. Trees			
	Y.P.	S.P.	L.P.	Est.Cost
Plan III. Areas No. 1, N½ of 2, and No. 5 (see map). (Marblefork and N½ of Middlefork watersheds) This includes areas which are easily accessible and which are seen at close range by practically all visitors to the Park; maintenance work can be carried out to advantage because of good road and trail facilities.	295	50	150	$3,740
Plan IV. Areas No. 1, N½ of 2, Nos. 4 and 5 (see map). This plan contemplates the same program as Plan I with the addition of the Southfork watershed; the latter contains some rough country which is difficult of access, but it composes a relatively small and complete entomological unit, with very good chances for success of the work. Future plans for development of this section of the Park will place considerable emphasis on the preservation of the yellow pine and sugar pine type which surrounds the Garfield grove of big trees.	345	75	150	$4,110
Plan V. Areas No. 1, N½ of 2, N½ of 3 and No. 5 (see map) This substitutes the more accessible north half of the Eastfork watershed for the Southfork. Much of this area can be reached by roads, and it includes the Atwell's Mill district, through which a considerable amount of travel passes. However, cooperation of private owners and the National Forest will be necessary to the successful consummation of the project, as the infestation involves lands not owned by the National Park around Silk Bench Mountain, Oriole Lodge and east of Atwell's Mill. It has the disadvantage of working a control area between two untreated areas without complete topographic or type barriers. It will probably be best, if this plan is considered desirable, to go one step farther and work the entire infestation in all watersheds, as has already been suggested.	303	146	150	$3,634

The south half of Areas 2 and 3 were not mentioned in Plans III, IV and V because these regions are very difficult of access and do not stand out conspicuously from points of vantage.

Any of the plans proposed can be put through during the spring of 1931, from both the entomological and administrative standpoints, if funds are made available by March 1.

Under Plans III, IV and V, infestation within a few miles of the control areas will be left untreated. The object of the control will be to hold the infestation in the selected areas to a minimum until the epidemics in the adjoining areas subside and natural factors of control gain the upper hand. It is expected that some infiltration of beetles into the control area will occur; but our experience with the western pine beetle indicates that this will not be of sufficient volume to nullify the effects of the control work under the barriers which exist for those areas.

Factors Determining Necessity for Insect Control

In determining the necessity for forest insect control campaigns within a national park there is no definite standard upon which to base the necessity. Each national park has what might be called a standard of its own, depending largely upon the interest of the park administrative force. This situation unquestionably tends toward varying definitions of necessity, as an insect attack might in the mind of one superintendent warrant treatment, while in another park an exactly similar condition might seem unimportant. Because of this lack of standard the following types of forested areas are suggested as a basis for determining the need for insect control work in any national park:

1. Areas of intensive use
2. Areas of prospective intensive use
3. Areas of important scenic or aesthetic attraction
4. Areas threatening protected areas
   a. Within the national park
   b. Outside the national park
5. Areas for study and research
6. Areas of unusual fire hazard

1. Areas of Intensive Use. A general agreement no doubt exists upon the necessity for protecting areas of intensive use, such as campgrounds, main traveled roads and administrative areas. It is important that each portion of a park be protected from insects because

A. Healthy trees are necessary for cover. That healthy trees in a campground or administrative area are necessary is acknowledged because the trees are required for shade and beauty. In many instances the same arguments might be presented for protecting trees along main traveled roads, particularly park entrance roads and roads in and near centers of intensive public use. Where there are pure pine stands this consideration becomes particularly acute because of the possibility of roadside trees being entirely wiped out in an epidemic (Photo No. 3)

B. Reproduction is almost entirely suppressed. Because of trampling by great numbers of visitors reproduction is stumped out and the ground often pounded down to a hard, brick-like surface which offers slight possibility for the germination of tree seeds. Areas which are used to this extent must naturally have the trees carefully protected, because the situation becomes closely analogous to the city park. In this regard, protection of the trees from visitors frequently becomes more of a problem than protection from insects.

C. Snags are dangerous. That dead trees are dangerous, either from the snags crashing down or from falling branches, is proven through even a very short experience in a national park. The elimination of dead trees in the areas of intensive use therefore becomes a regular part of park maintenance. This hazard, however, can be almost completely overcome by protecting the trees from insect attacks and by cutting and treating those trees that are attacked while the insects are present.

That Sequoia National Park has followed very closely the above considerations is illustrated by the control work conducted at Lodgepole Camp and along the roads to the campground. The forest cover in the camps of Giant Forest has also been carefully watched. Roadside protection, however, has not been consistently carried out because of a shortage of funds and because the cover is a mixed type which soon hides the dead pines. Snag clean-up along the roads, however, is carried on with maintenance funds when the dead trees become numerous enough to be unsightly or dangerous. It therefore seems reasonable that provision should be made to cut infested trees when the insects are present, thus protecting the remaining trees and reducing the number of snags.

2. Areas of Prospective Intensive Use. The plan of development for a national park makes possible the determination of insect control in areas that are not now being intensively used, but will be in the future. These regions of prospective development should be protected for the following reasons:

A. Healthy forests make attractive development areas
B. Snags are dangerous and unsightly
C. Openings caused by insect-killed trees are slowly filled by young trees
D. Group killing of mature trees often results in dense reproduction unsuitable for development purposes

The reasons for conducting insect control work in an area that will become a center of development in the future are very nearly the same as those applied to an existing region of use. These reasons, however, depend largely upon the type of cover and should be modified accordingly. In a pure stand, where an epidemic might kill nearly all the mature trees, treatment should be carried on because the young growth might not have time to form suitable cover or might come in so thickly as to ruin an otherwise attractive camp. This is well illustrated in Sequoia National Park at Hockett Meadows, which is an area of prospective use and is now ideally situated for camping (Photos Nos. 7 and 8). The bark beetle epidemic threatening this region from Horse Creek warrants treatment because the cover is almost pure lodgepole pine.

In places of prospective use where the cover is mixed, treatment might not be necessary, because the combination of species usually insures adequate cover even if one species is entirely wiped out. The situation in the Southfork illustrates this possibility, because the cover is mixed yellow pine and hardwoods. As the place is rather difficult of access, treatment may not be warranted, because the young pines and associated species will still offer adequate cover.

3. Areas of important scenic or aesthetic attraction. Ideas on the importance of the above two factors are not apt to vary greatly with the human equation; but opinions on the necessity for preserving scenic attraction will depend upon personal judgment or belief. For this reason protection of scenery might be based upon the following considerations:

A. Visibility. Within each national park there are points from which can be viewed great expanses of terrain that usually include forest-covered slopes. The forests in view from such points may warrant treatment, depending upon the two following considerations: but if an area is remote and not visible from a point of view, treatment would be unwarranted unless it came under Type of Area 1, 2, 4 or 6.

The experience of men contacting park visitors indicates that the public does not notice the dead trees in a forest unless the number is unusually conspicuous. Ordinarily, the situation from a point of view is geological--great mountains or yawning chasms--so that the forests within view are unnoticed, due to the attention being focused upon the major spectacle and because trees are "only trees" to the average person.

B. Accessibility. Occasionally there are regions visible from a point of view that deserve treatment aesthetically, but the difficulty of gaining access to the area might make control work impracticable. Determination of treatment in such a case must necessarily depend upon individual judgment; but unless the situation is unusually extreme it should be remembered that any insect situation may in two or three years be entirely obliterated by the dead trees becoming inconspicuous and the growing trees filling the spaces.

The fact that a region is accessible to trail parties does not necessarily recommend it to treatment, because an area of forest containing many insect-killed trees might be very interesting and educational, even though not beautiful. This point is further elaborated under "Type of Area No. 5".

C. Forest type--pure stand or mixed stand. In determining the necessity for control on aesthetic reasons, the type of cover is an important consideration. If the forest is a pure stand of pine, an epidemic would possibly leave an unsightly scar that would detract from an otherwise beautiful vista. This is no doubt best illustrated in Crater Lake Park, where devastation of the pure lodgepole stands has resulted in desolation.

In forests, however, consisting of a mixture of pine with either fir, oak or chaparral, there is a question as to the necessity for control, even though every pine in the stand is killed. This supposition is based upon the fact that the associated species will maintain practically intact the appearance of a forested slope, even if the pine is eliminated. The dead trees in a mixed type quickly become inconspicuous; and from a standpoint of beauty, to the distant observer a slope might just as well be covered with chaparral as with trees.

In Sequoia National Park, Moro Rock is a very popular point of view from which is obtained a most unusual outlook on the Sierra Nevada Mountains; but within easy eyesight from Moro Rock are pine forests which to the initiated disclose many insect-killed trees (Photo No. 5). To the park visitor, however, these trees are unnoticed. Furthermore, even if the fading trees were so numerous as to be noticed, the south half of Area 2 (see map) would not warrant treatment because of expense due to inaccessibility and also because it is in a mixed conifer-oak type which easily camouflages the dead trees.

4. Areas Threatening Protected Areas. Because entomologists have definitely determined that tree-destroying insects travel for considerable distances, it is important that regions adjacent to or within flight distance of protected areas be treated. This is purely an entomological consideration, and the safety zone around a protected area depends upon the species of insect, the topography and type barriers.

Within the National Park the problem can be quite easily solved. In the Sequoia this fall the lodgepole pine at Willow Meadow was treated to protect Lodgepole Camp, as the two areas are within flight distance of each other.

It is also equally important that areas outside the Park, such as national forests or privately-owned forests, be protected by treating within the park those regions which might be foci of infestation to the outside areas. This consideration, however, becomes important only when the adjoining agency is conducting an insect control campaign.

It goes without saying that the cooperation of neighbors of the Park is required when protected areas within the Park are exposed through insect conditions outside the Park.

5. Areas for Study and Research. In spite of the fact that the national parks were set aside to preserve and protect works of nature, this purpose seems to gain slight consideration in planning insect control campaigns. Even in the face of programs for park development and insect and forest fire protection there is still room for setting aside research, study or wilderness areas that will not hamper development nor threaten protected regions. It is not the purpose of this report to discuss this question, but it is a point that should be considered by park administrators if a definite national park policy is to be established concerning forest insect control.

6. Areas of Unusual Fire Hazard. Frequently the argument is presented that insect-killed forests present a serious fire hazard. This factor depends largely upon the type of forest, ground cover, site, slope and exposure. As a whole it can be overrated, but there are instances where it becomes an important factor. In pure stands of pine growing upon dry slopes or in stands adjoining hazardous brush country, the forest fire danger is a matter for attention.

In contemplating insect control because of a possible increased fire hazard, the danger element in a killed tree is usually considered to be the standing snag. From forest fire danger alone, except in unusually hazardous areas, an insect control campaign simply to eliminate snags hardly seems warranted if the region has the usual forest fire protection, detection and suppression methods.

Explanations of the above types of forested areas have purposely been made brief, although much can be written on the subject. It is hoped that this report, based upon experiences in Sequoia National Park, will result in the establishment of a definite policy, in order that the work in the various parks may be conducted under the same standards.

Plans III, IV and V, described herein, are entomologically feasible and administratively reasonable; but at present there is no clear-cut policy upon which to base a choice. For this reason, work started on any one of the plans, or modifications of them, might at a later date prove to be wasted or even detrimental, because of the possibility of the future establishment of a national park standard for insect control.

Except during the last two years, control work in Sequoia National Park for the past fourteen years has been conducted spasmodically, along no definite plan, and without consideration of park development or national park principles. The work so far accomplished has been carried on without means being made available for follow-up work, and has resulted in treated areas relapsing into a condition of infestation. Aside from the Hockett Meadow area, no definite recommendations have been made in this report, because there is no established national park policy regarding forest insect control upon which to base recommendations.

Photo No. 1. Yellow pine killed by western pine beetle beside General's Highway near Eleven Range Point during the summer of 1930. At the time this photo was taken, in October, the foliage was sorrel color and shows white through the use of panchrmmatic film. This tree stands near the border of the brush and yellow pine type and, together with the dead snag near it, illustrates the depletion of mature trees on these sites.

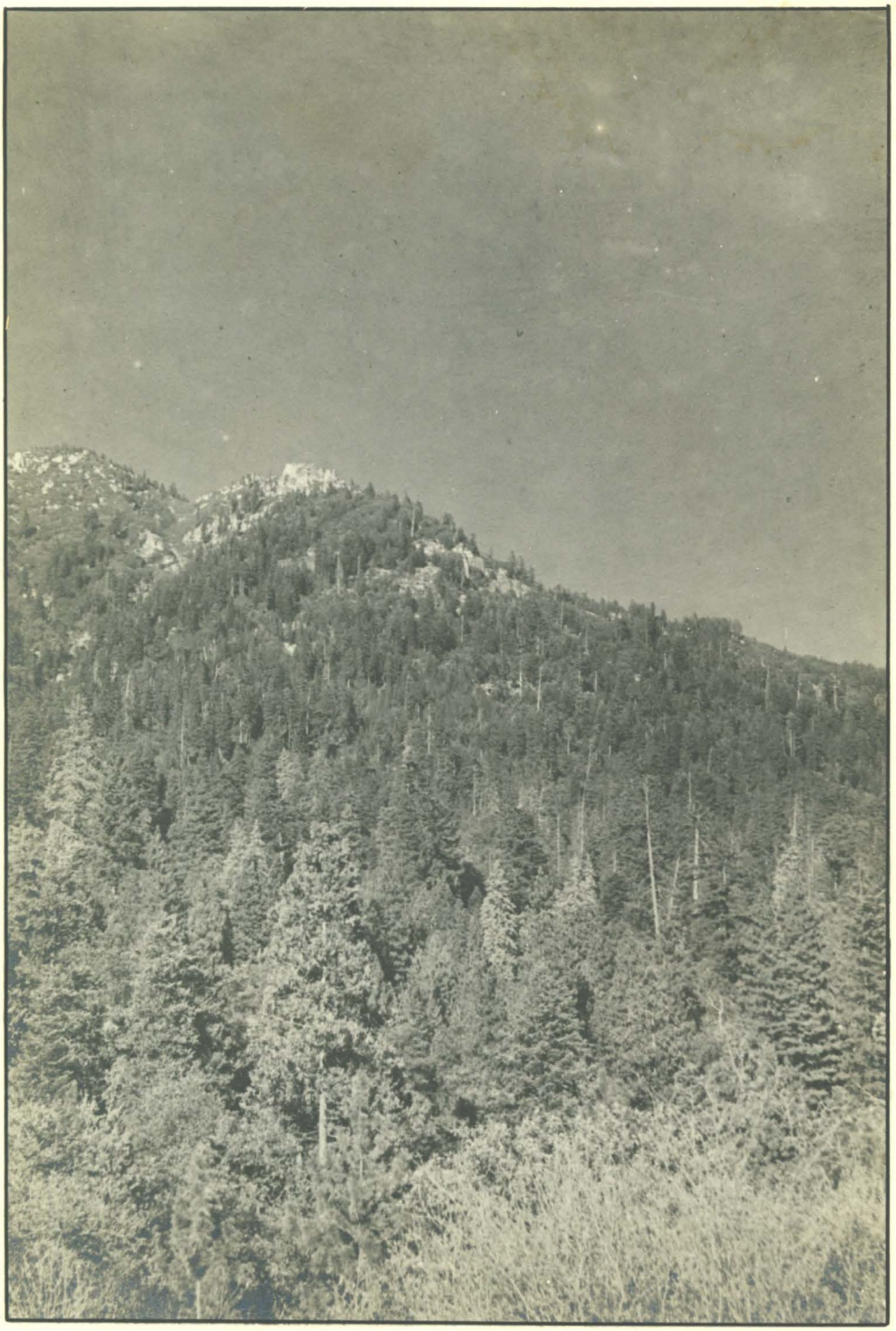

Photo No. 2. Western pine beetle infestation on the Tule River watershed south of Sequoia National Park. In the field of this picture there are fifteen trees killed during the summer of 1930 which can be distinguished by light-colored foliage. The infestation in the vicinity of Oriole Lodge is somewhat heavier than this, as the infested trees occur in large groups.

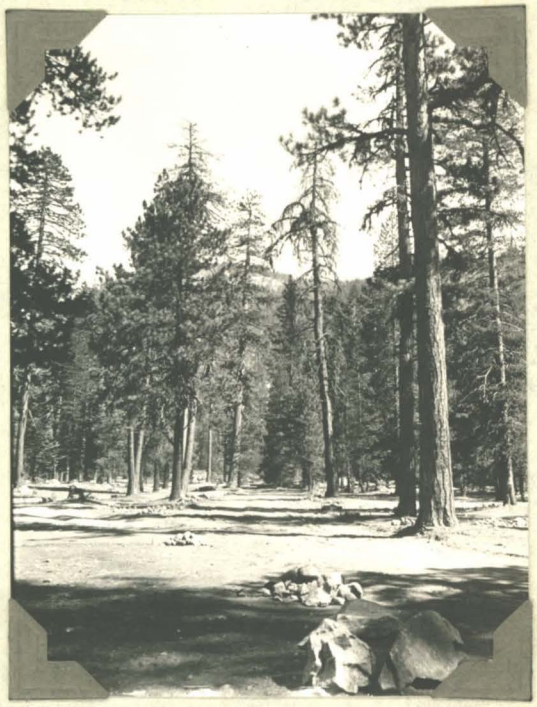

Photo No. 3. Campground at Lodgepole Camp, showing scarcity of cover. The dead trees are Jeffrey pine, killed by the Jeffrey pine beetle in 1928. Insect control on campgrounds protects the stand and reduces the danger from falling snags.

Photo No. 4. Another view of the Lodgepole Camp area, showing groups of lodgepole pine which are highly valuable as cover. The mountain pine beetle was rapidly killing the lodgepole pine on this area until control work started in the fall of 1928 checked the loss.

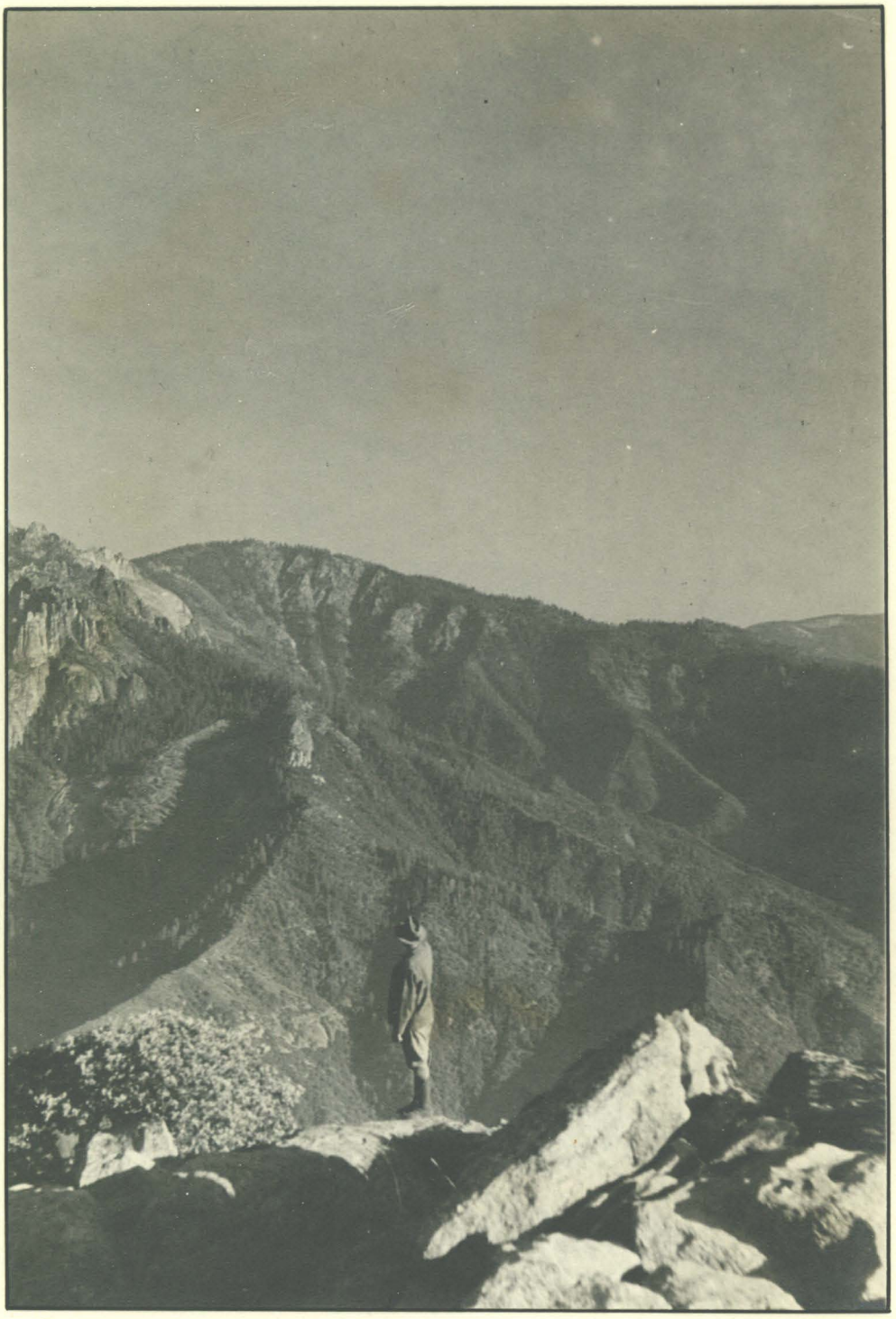

Photo No. 5. View of Paradise Creek watershed from Moro Rock. This illustrates the inaccessible type of country in which some of the heaviest infestations of the Park are now located. The sparse forest of yellow pine bordering the brush areas is being rapidly killed by the western pine beetle. The desirability of carrying on insect control work under these conditions is open to question.

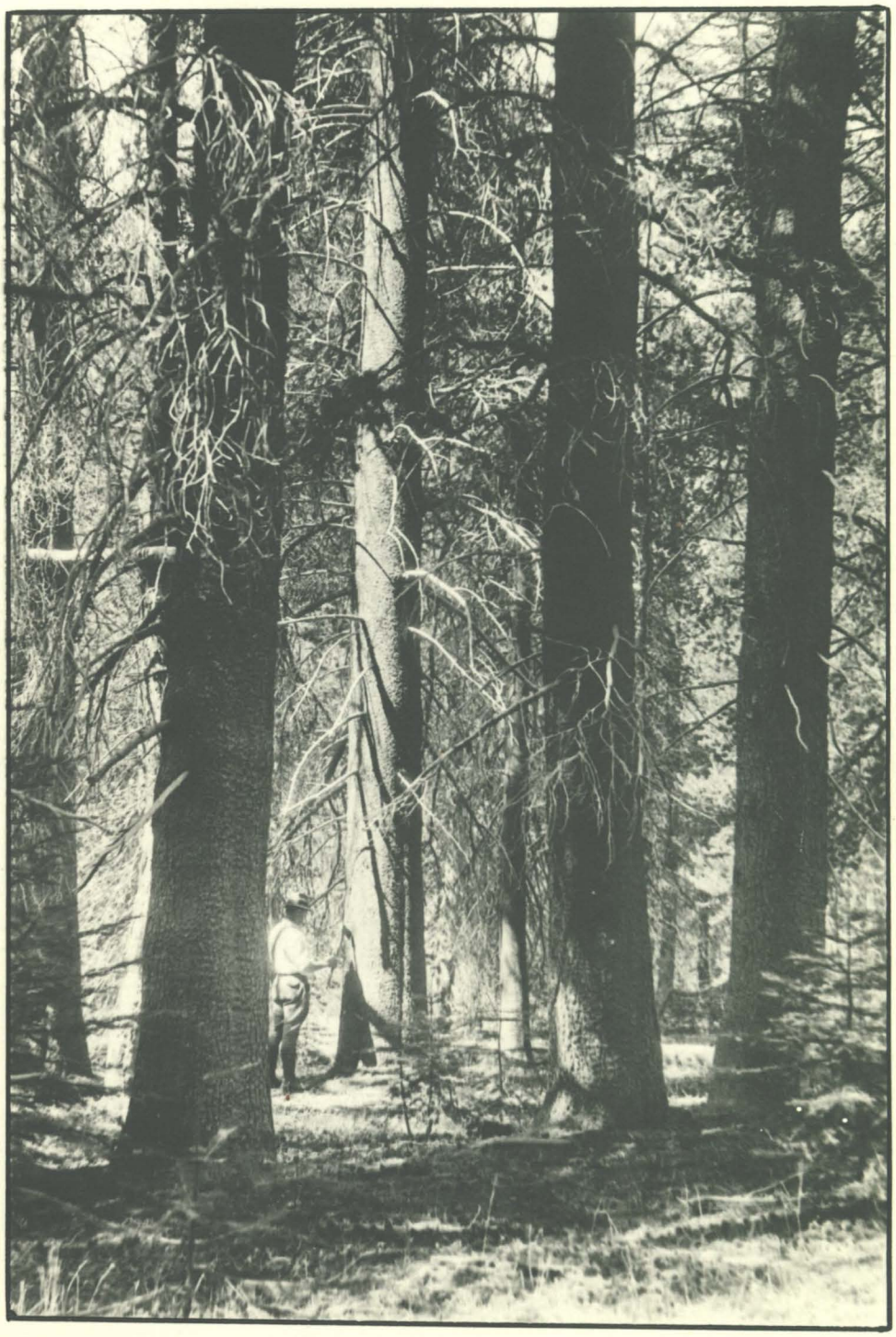

Photo No. 6. Forest of mature lodgepole pine at Willow Meadow. This is the parklike type of forest which covers much of the Hockett Plateau, where the mature trees are highly susceptible to epidemics of the mountain pine beetle, which kill a large percentage of the stand.

Photo No. 7. Campground at Horse Creek showing shelter trees, which are lodgepole pine. Each of the blazed trees shown in this picture was attacked by the mountain pine beetle in 1930 and will be dead next season. The infestation center which has been building up here threatens the entire lodgepole forest on the Hockett Plateau.

Photo No. 8. Conditions following an old killing of lodgepole on Horse Creek. A heavy thicket of young trees is coming in under the dead snags. This condition is undesirable for camp grounds and presents a dangerous forest fire hazard.

INFESTATION AREAS, SEQUOIA NATIONAL PARK, SEASON OF 1930

Name of Area	Estimated Number of Infested Trees (Overwintering, 1930)			Estimated Cost of Control
	Y.P.	S.P.	Lodgepole	
Control work to be undertaken, spring of 1931				
1. Marblefork-Yucca Creek	90	20		$920.
2. Middlefork	225	60		$2,400.
3. Eastfork	650	115		$6,350.
4. Southfork	140	25		$1,370.
5. Horse Creek			150	$600.
				$11,640.
Control work completed, October 1930				
1[a] Lodgepole Camp 56 J.P.		4	41	$475.20

Areas infested by mountain pine beetle in lodgepole pine

Big Baldy
Bearpaw Meadow
Stony Creek Meadow
Kettle Pk
Lost Lake
Twin Peaks
Ranger Lakes
Meadow
Ranger Cabin Meadow
Colony Meadow
Mt Silliman
Long Meadow
Canyon
MUIR GROVE BIG TREES
Cahoon Meadow
Table Meadows
Big Bird Lake
Little Baldy
Halstead Meadow
Tokopah Valley
Ridge Pole
Elizabeth Pass
BIG TREES
Long Meadow
Alta Pk
Tharps Rock
Panther Pk
Merten Meadow
Lonepine Meadow
Crystal Cave
Alta Meadow
Yucca Mt
Circle Meadow
Bearpaw Meadow
Colony Pk
Crescent Meadow
Back
Switchback
Panorama Pt
Ash Peak Lookout
Hospital Rock Ranger Station
Redwood Meadow
Adams Pk
Potwisha Camp
Frys Pt
Cactus Point
Sand Meadow
Castle Rocks
Shepherd Pk
Paradise Ridge
Paradise Peak Lookout
Swamp
Mashburn Cove
Kaweah
Hammond
River Hill
Table Mountain
Whole Lake
Atwell Mill Ranger Station
Glacier Gap
Glacier Pass
Sawtooth
Mineral King
Mineral Pk
Farewell Gap
Horn Mt
Cahoon Mt
Homers Nose
Cahoon Meadow
Hockett Meadows
Sand Meadows
Mitchell Meadows
South Fork
Cabin Meadow
Quinn Pk
Soda Butte
Hidden Lake
Sheep Mt
Grouse Valley
Upper Grouse Valley
Dennison Peak
Summit Meadow
Garfield
Atwell Mill
SEQUOIA
NATIONAL GAME REFUGE
1
1A
2
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4
5

BARK BEETLE INSECT SURVEY, SEQUOIA NATIONAL PARK, OCTOBER, 1930

COUNTS AND ESTIMATES OF INSECT-KILLED TREES
MARBLE FORK AREAS

(WILLIS, BARK BEETLES)

AREA 1

Estimates--Marble Fork and Tucca Creek

Area	Viewpoint	No. Trees Counted		Factor	Total Estimate	
		Y.P.	S.P.		Y.P.	S.P.
W. Slope Marble Fork	Admiration Point	11	2	2	22	4
do	1 mi. S of bridge	20	6	2	40	18
W. Slope Colony Mill Ridge	Ash Mt. Trail	30	-	4	120	-
Crystal Cave	Crystal Cave Tr.	7	4	2	14	8
Black Oak Tr.	Trail strip	8	4	1½	12	6
Totals					208	30

Check Area--Colony Mill Road Strip

Area covered: 5 chains on each side of road, beginning three-quarters of a mile beyond Colony Mill Point and extending to junction with Giant Forest Road; distance 7.5 miles.

Yellow pine losses:		Trees	Volume
1929	D.b. summer	7	9,170
	D.b. winter	10	4,145
	D.m.	1	25
1930	D.b. summer	8	21,300
	D.b. winter	3	11,749
	Totals	27	46,990

Sugar pine losses:			
1929	D.m. summer	5	2,260
	D.m. winter	4	6,210
1930	D.m. summer	1	4,700
	Totals	10	13,170

AREA 1a

Estimates--Lodgepole Camp; Lodgepole and Jeffrey Pine Losses

Date	Area	Acres	1930 D.m.	1930 D.j.
Sept. 25	Willow Meadow	18	28	1
Oct. 2	Lodgepole Camp	60	11	22

General cruise made in Clover Creek Basin in lodgepole October 3, 1930; three 1930 and three 1929 trees noted. Five trees near trail in lower Cahoon Meadow.

AREA 2

Estimates--Middle Fork of Kaweah

Area	Viewpoint	No. Trees Counted Y.P.	S.P.	Factor	Total Estimate Y.P.	S.P.
Dome Creek	High Sierra Trail	14	--	4	56	--
Bet. Dome and Castle Crs.	do	20	2	4	80	8
Castle Creek	do	12	5	4	48	20
Merten Creek	do	60	1	2½	150	3
E. of Castle Cr.	7-mile Hill Trail	14	4	3	42	12
Buck Canyon	do	10	1	3	30	3
River Valley	do	18	4	4	72	16
Panther Creek	High Sierra Trail	21	10	3	63	30
Under Castle Rocks	Moro Rock	20	--	3	60	--
W. Slope above Paradise Cr.	do	20	--	3	60	--
E. Slope Upper Paradise Cr.	Paradise Trail	47	1	2½	117	3
Totals					752	95

Estimates--East Fork of Kaweah

Area	No. Trees Counted: Y.P.	S.P.	Factor	Total Estimates: Y.P.	S.P.	Both
Bet. Horse Creek and Deer Creek:	32	15	3	96	45	141
W. Slope Horse and Cahoon Crs:	13	4	4	52	16	68
Redwood Creek	54	5	4	216	20	236
Flapjack "	30	4	3	90	12	102
Eden "	10	1	4	40	4	44
Salt "	96	22	4	384	88	472
Oriole "	108	36	2½	270	90	360
Grunigen "	39	3	3	117	9	126
Squirrel "	89	5	3	267	15	282
Silk Ranch Mt.	99	5	3	297	15	312
Upper E.Fork--Atwell to Hockett Tr. Bridge:	22	4	4	88	16	104
Totals				1,917	330	2,247

Check Area--Atwell's Mill

Acreage covered--approximately 100

	Yellow pine losses:	Trees	Volume
1929	D.b. summer	15	22,910
	D.b. winter	43	26,040
	D.m. "	4	2,380
1930	D.b. summer	16	23,130
	D.b. winter	15	21,130
	Totals	91	95,590

	Sugar pine losses		
1929	D.m. summer	2	6,600
	D.m. winter	1	20
1930	D.m. summer	1	4,780
	Totals	4	11,400

Count of this area made on Hockett Meadow Trail
With binoculars, 42; without, 25; factor, 2½

Check Strip--Oriole Lake

Area covered: 5 chains on each side of road from bridge to crest of hill:

	Yellow pine losses:	Trees	Volume
1929	D.b. summer	9	18,750
	D.b. winter	20	49,150
1930	D.b. summer	1	3,000
	D.b. winter	4	7,750
	Totals	34	80,610

AREA 4

Estimates--South Fork of Kaweah

Area	Viewpoint	No. Trees Counted Y.P.	No. Trees Counted S.P.	Factor	Total Estimate Y.P.	Total Estimate S.P.
Cedar Cr.-Basin	Garfield Trail	19	3	3	57	9
Pigeon Creek	do	14	3	3	42	9
Putnam Canyon	Peak 2 mi.east of Clough's Cave	14	4	2½	35	10
Snowslide	do	11	5	3	33	15
Slide Canyon	do	40	10	2½	100	25
Upper Basin South Fork	do	20	5	3	60	15
Totals					327	83

AREA 5

Cheek Area--Horse Creek--Lodgepole Losses

Date	Area	Acres	1929 p.m.	1930 p.m.
Sept. 22,23	Horse Creek Camp north of trail crossing	17	9	22
	South and west of trail crossing	6	13	18
	North of Horse Creek	6	1	12
	Totals		23	52

Cheek Area--Hockett Meadow--Lodgepole Losses

Date	Area	No. Trees Counted 1929	No. Trees Counted 1930	Total
Sept. 23	Cow Creek north of Cahoon Lookout Trail	1	2	3
	Whitaker Creek north of junc.with Cow Cr.	5	3	8

Hockett Meadow stand fairly clean; six trees noted below trail as it leaves Lodgepole Flat, going toward Atwell's Mill.